

**Structural Design and Test Loads for the GLAST Anti-Coincidence
Detector (ACD)**

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1.0 Introduction

This document summarizes the current set of design and test loads for the GLAST Anti-Coincidence Detector (ACD) subsystem. The ACD is a subsystem of the Large Area Telescope (LAT) instrument that is the primary instrument for the GLAST observatory. The GLAST observatory will be launched on a Delta II 7920H-10 launch vehicle. This document covers the requirements for quasi-static design loads and for dynamic environments including swept sine vibration, random vibration, acoustic and shock. The contents of this document will be periodically updated to reflect the latest design and analysis information.

2.0 Applicable Documents

- 1) General Environmental Verification Specification for STS & ELV Payloads, Subsystems and Components (GEVS-SE, Rev. A), GSFC System Reliability & Safety Office, June 1996
- 2) Delta II Payload Planners Guide, Boeing Aerospace, October 2000

3.0 Design Limit Loads

The design limit loads for the ACD subsystem are shown in Table 1. These load factors are intended for design of the ACD Tile Shell Assembly (TSA) and flexures. Assessment of loads in the Base Electronics Assembly (BEA) should be performed using a coupled LAT/ACD model because of the redundant interface between the ACD and LAT. Table 2 provides the design limit loads for components and secondary structure weighing less than 22.7 kg (50 lbs). These load factors are specified as design limit and should be multiplied by a factor of 1.25 to achieve proto-flight levels. Design limit loads for components and secondary structure not covered by Tables 1 & 2 are provided in Appendix A.

Table 1. ACD Design Limit Load Factors (g)

Axis	Liftoff/Airloads	MECO
Thrust (Z)	+4.0	+6.8
Lateral	±5.0	±0.2
Notes:		
1. Load factors applied at the ACD CG		
2. Thrust and lateral loads applied simultaneously		
3. All possible orientations of the lateral load about the thrust axis shall be examined.		
4. Positive thrust value denotes compression at the S/C interface.		

Table 2. Component Design Limit Load Factors

Description	Acceleration (g)
Components < 22.7 kg	±12.0
Notes:	
1. Applied each axis independently	

4.0 Swept Sine Vibration Levels

The swept sine vibration levels are intended to envelope the low-frequency (<50 Hz) launch environment. The swept sine levels for the ACD were derived from a base-drive of the GLAST observatory using the sinusoidal vibration levels given in the Delta II Payload Planners Guide from 5 to 50 Hz. The swept sine levels for the ACD subsystem are shown in Table 3. The swept sine levels shown in Table 3 are acceptance levels and represent ACD net CG response. These levels should be multiplied by 1.25 to achieve proto-flight levels.

Table 3. ACD Sine Sweep Acceptance Test Levels

Axis	Frequency (Hz)	Level (g)	Sweep Rate (Oct/Min)
Lateral (X & Y)	5 - 15	3.5	4
	15 - 25	1.5	4
	25 - 35	1.5	1.5
	35 - 45	3.0	4
	45 - 50	3.8	4
Thrust (Z)	5 - 18	2.0	4
	20 - 40	4.0	4
	42 - 50	2.0	4
Note: 1. The test levels represent ACD Net CG response. 2. Input levels may be notched so that interface forces or response accelerations do not exceed flight loads predictions.			

5.0 Acoustic Levels

The maximum acoustic environment within the Delta II fairing occurs during liftoff and transonic flight. The acoustic environment produces the dominant high-frequency random vibration response in the ACD. The acoustic levels for the Delta II 7920H-10 launch vehicle are shown in Table 4.

Table 4. Delta II 7920H-10 Acoustic Levels

One-Third Octave Center Frequency (Hz)	Flight Level (dB)	Protoflight Level (dB)
31.5	121.5	124.5
40	124.5	127.5
50	128.5	130.5
63	130.0	133.0
80	130.5	133.5
100	131.5	134.5
125	132.0	135.0
160	132.0	135.0
200	132.5	135.5
250	133.5	136.5
315	134.5	137.5
400	133.5	136.5
500	130.0	133.0
630	127.0	130.0
800	124.0	127.0
1000	122.0	125.0
1250	120.0	123.0
1600	119.0	122.0
2000	118.5	121.5
2500	118.0	121.0
3150	117.0	120.0
4000	115.5	118.5
50000	113.0	116.0
6300	109.0	112.0
8000	105.0	108.0
10000	102.0	105.0
OASPL	142.8	145.8
Notes: Test Duration = 60 Seconds		

6.0 Random Vibration Levels

The high-frequency random vibration environment for the ACD is expected to be primarily driven by acoustic excitation. It is therefore not expected that a random vibration test will be performed as the ACD subsystem level. As a reference, the GEVS random vibration levels that have been attenuated for an overall ACD mass of 220 kg are shown in Table 5. The random vibration levels for components weighing less than 22.7 kg (50 lbs) are given in Table 6. Specific random vibration levels for ACD components not covered by Tables 5 & 6 are provided in Appendix B.

Table 5. ACD Random Vibration Levels (Mass = 220 kg)

Frequency (Hz)	ASD Level (G^2/Hz)	
	Qualification	Acceptance
20	0.01	0.01
20-50	+2.3 dB/Oct	0 dB/Oct
50-800	0.02	0.01
800-2000	-2.3 dB/Oct	0 dB/Oct
2000	0.01	0.01
Overall	5.7 Grms	4.5 Grms
Notes:		
1. Test duration = 1 min/axis		

Table 6. ACD Component Random Vibration Levels (Mass < 22.7 Kg)

Frequency (Hz)	ASD Level (G^2/Hz)	
	Qualification	Acceptance
20	0.026	0.013
20-50	+6 db/Oct	+6 dB/Oct
50-800	0.16	0.08
800-2000	-6 dB/Oct	-6 dB/Oct
2000	0.026	0.026
Overall	14.1 G_{rms}	10.0 G_{rms}
Notes:		
1. Test duration = 1 min/axis		

7.0 Shock Levels

It is expected that the shock inputs to the LAT instrument will be driven by pyro firings at the spacecraft separation plane and that actuators on-board the spacecraft will be of a low-shock type of device. Since the ACD interface is not located near a shock source, the shock levels at the ACD will be benign and that shock testing will be performed at the observatory level. The maximum expected flight shock levels at the LAT/spacecraft interface are provided in Table 7 for reference. These levels represent the shock levels for a 6915 PAF as defined in the Delta II Payload Planner's Guide and have been attenuated by 6 dB to account for the distance and number of joints between the separation plane and the LAT instrument interface. The shock levels shown in Table 7 are considered to be conservative for the ACD and if a specific component cannot handle these levels, then a more detailed analysis can be performed to refine the shock estimates at the component mounting location.

Table 7. LAT Interface Shock Response Spectrum (Q=10)

Frequency (Hz)	Flight Level (g)	Protoflight Level (g)
100 - 350	50	70
350 – 1700	12.3 dB/oct	12.3 dB/oct
1700	1250	1750
1700 – 4000	5.6 dB/Oct	5.6 dB/Oct
4000 – 5000	2750	3850
5000 – 10000	-9 dB/Oct	-9 dB/Oct
10000	1000	1400

Appendix A

Design Limit Loads for Components and Secondary Structure

A1.0 ACD Panel Loads due to Acoustics

The limit loads shown in Table A1 account for the loading on the ACD shell due to launch vehicle acoustics. The loads specified in the table were calculated using the protoflight acoustic environment given in Table 4 for the Delta II 7920H-10 configuration. These loads represent an additional set of load cases to those specified in Table 1.

Table A1. ACD Panel Acoustic Limit Loads

Panel Location	Limit Load (g)
Side	5.3
Top	9.5
Notes: 1. Loads applied to each panel independently 2. Loads applied normal to panel surface	

APPENDIX B

Random Vibration Levels for ACD Components

B1.0 ACD Component Random Vibration Levels

The ACD random vibration levels are covered by Tables 5 and 6. There are no additional component random vibration levels that have been identified at this time. This section will be updated to include this information when available.